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A STUDY ON REDUCING OR ELIMINATING AIR CONDITIONING IN
THE PERSHING GUIDANCE AND CONTROL COMPARTMENT

15 January 1963



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**A STUDY ON REDUCING OR ELIMINATING AIR CONDITIONING OF
THE PERSHING GUIDANCE AND CONTROL COMPARTMENT**

by

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**DA Project No. 1-B-2-79191-D-678
AMC Management Structure Code No. 5292.12.127**

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U. S. Army Missile Command
Redstone Arsenal, Alabama**

ABSTRACT

This report presents a study on the possibility of removing or reducing the air conditioning now required by the PERSHING guidance and control compartment. It contains a climatical study to establish the operational environment and described proposed laboratory test program to determine guidance and control compartment operating temperature, suggesting the specific tests to be performed on a missile, and the missile modifications and test equipment required. Also included are manpower and cost estimates for the proposed test program. This report describes a system test. A second report is under preparation which will detail a follow-on component evaluation based on the systems information obtained.

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A STUDY ON REDUCING OR ELIMINATING AIR CONDITIONING OF THE PERSHING GUIDANCE AND CONTROL COMPARTMENT

I. INTRODUCTION

This report is designed to provide the PERSHING Project Office with a proposed method of determining if it is feasible to reduce or eliminate the air conditioning of the guidance and control compartment, with the final decision to be based on the results of a fairly detailed test phase. The desirability of eliminating air conditioning stems from the necessity of removing the turbine as a prime mover in the primary power pack. The turbine produces a whine which has been proven to be dangerous to the hearing of the operating personnel. Without the power requirement of the air conditioner, a more conventional and less hazardous means of driving the power source could be used.

The PERSHING weapon system is designed as a mobile weapon system, capable of delivering a short range missile on a target within minutes after arriving at the launching site, and capable of being launched in any climate and from almost any terrain. The basic weapon system is comprised of five units -- missile, erector-launcher, programmer test station, primary power pack, and communications set, all of which can be transported by four XM474 vehicles or helicopters.

In a prelaunch countdown, the electrical power, high pressure air, and temperature-conditioned air are produced by the primary power pack. The electrical power is used by the programmer test station to perform the prelaunch test and checkout of the missile and to preset the guidance functions for a particular flight. The high pressure air and conditioned air are delivered directly to the missile to supply the guidance system with compressed air for flight and to maintain the desired temperature in the guidance and control compartment of the missile during the countdown. If the cooling cycle of the conditioned air can be eliminated, the power requirement of the primary power pack may be reduced, permitting the turbine engine to be replaced by a diesel or gasoline reciprocating engine.

A reasonable operating temperature for the guidance and control compartment will be established, based on a climatical study defining the environment. The new temperature will be based on typical conditions of extreme climates rather than the worst conditions expected in these areas. The performance of the system will be evaluated at both the nominal and extreme temperatures, and, if feasible, a down-rated performance CEP will be established for the extreme condition.

In extremely high temperatures it may be necessary to precondition the missile prior to the countdown to reduce the effect of solar radiation and the inclosure. This accumulation of heat could be reduced by continuously circulating air through the guidance and control compartment.

This report is divided into two parts: the first part is concerned with a system test to establish a new maximum operating temperature for the guidance and control compartment, and the second with component evaluation and redesign indicated by this system test.

II. CLIMATICAL DATA

Since the air-cooling function of the air-conditioning system is to be reduced or eliminated, the prime consideration is how high the guidance and control compartment temperature will rise. The determining factor is the environment in which the missile is to operate. Temperatures have been recorded as high as 136°F (Azizi, Tripoli) and solar radiation up to 111 watts per square foot (Mount Aunconquila, Chile) but measurements as high as these are rare.

A. Background

1. High Temperature Areas

The most predominantly hot areas of the world are: the Great Plains, the Rio Grande Valley and the San Joaquin Valley of North America; the Chaco and Western Pampas of Argentina; the Sahara, the Nile Valley, and the coastal regions of the Sudan (along the northern part of the Indian Ocean and the Red Sea) on the African Continent; the Mesopotamia Valley and the deserts of Saudi Arabia in the Middle East; the Ganges Valley and the monsoon areas of India; and the grasslands of Australia.

As illustrated on the world map in Figure 1, all these areas have at least one day during the hottest month of the year with a maximum temperature above 110°F. Figures 2 and 3 show the areas having at least one day during the hottest month with temperatures above 115° and 120°, respectively.

In considering an area where temperatures of 110°F occurs, it should be realized that these conditions occur only during a few days each year and last only from two to four hours during each of these days, so that the percentage of time that an extremely hot temperature might occur in worldwide conditions is fairly small.*

2. High Solar Radiation Areas

Solar radiation in a hot desert is estimated at 105 watts per square foot, but radiation levels recorded in the Mojave Desert average approximately 10 percent below the estimate.

*See Table, page 6.

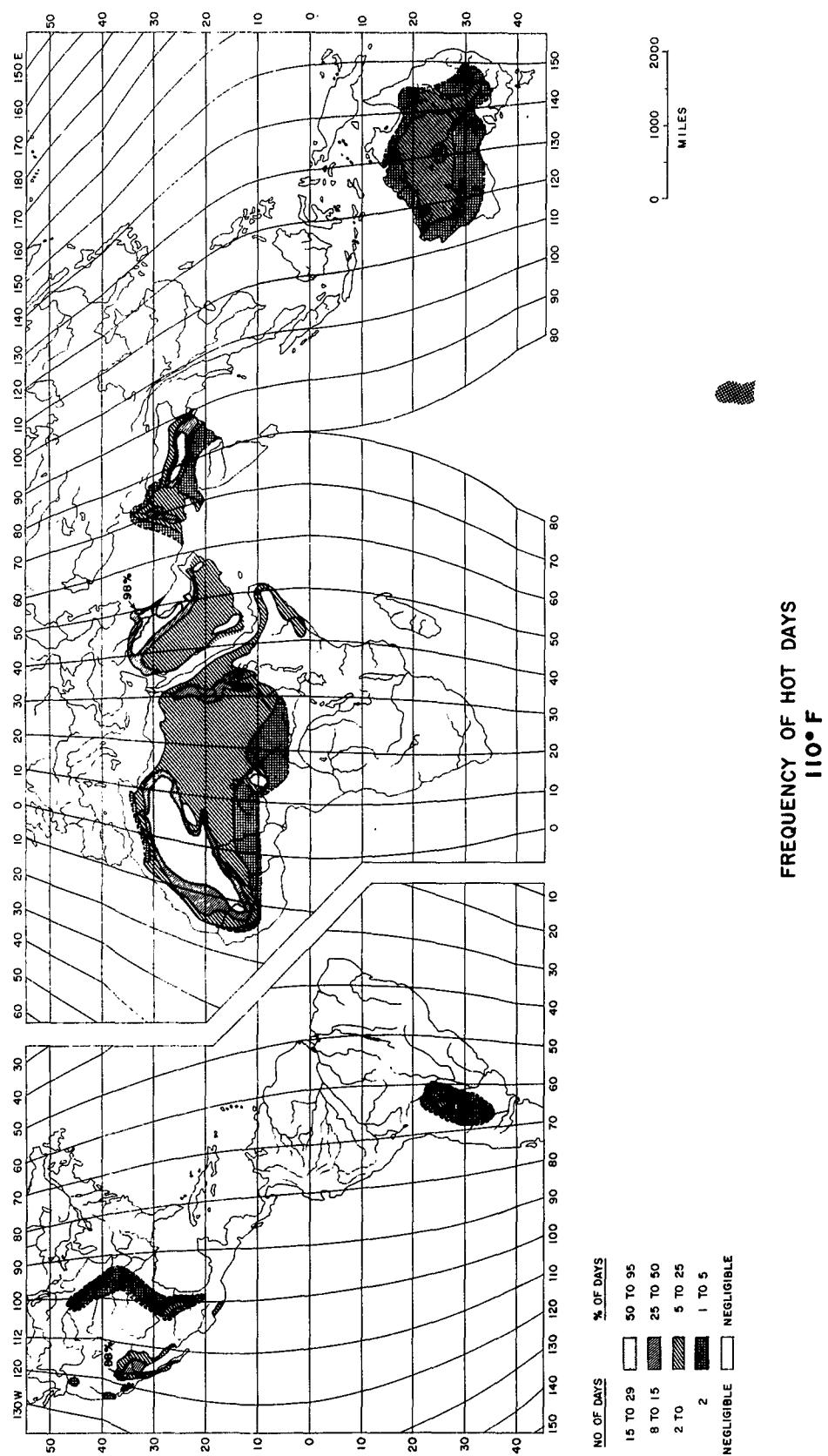


Figure 1. FREQUENCY OF HOT DAYS WITH MAXIMUM TEMPERATURES
AT OR ABOVE 110°F

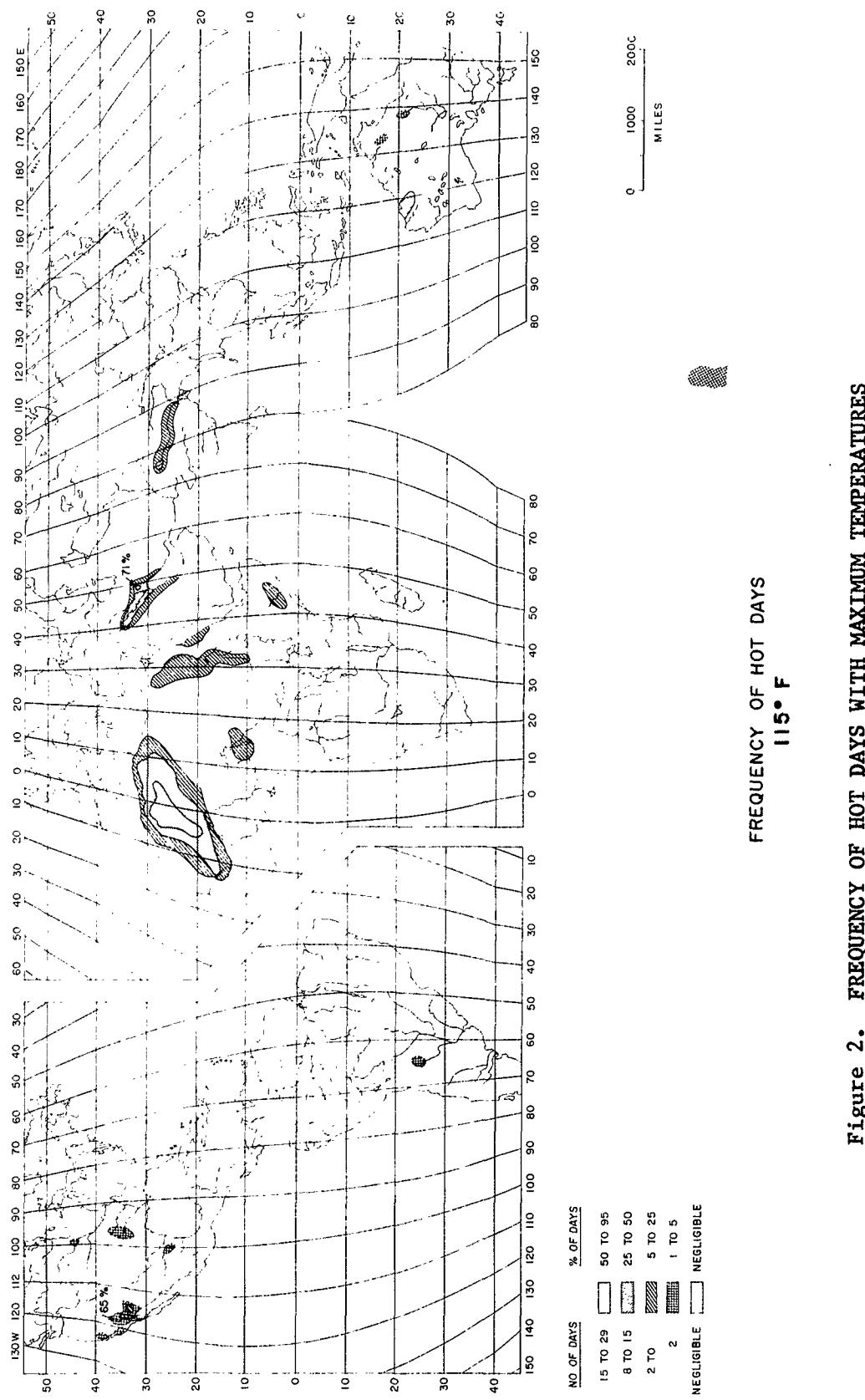


Figure 2. FREQUENCY OF HOT DAYS WITH MAXIMUM TEMPERATURES
AT OR ABOVE 115°F

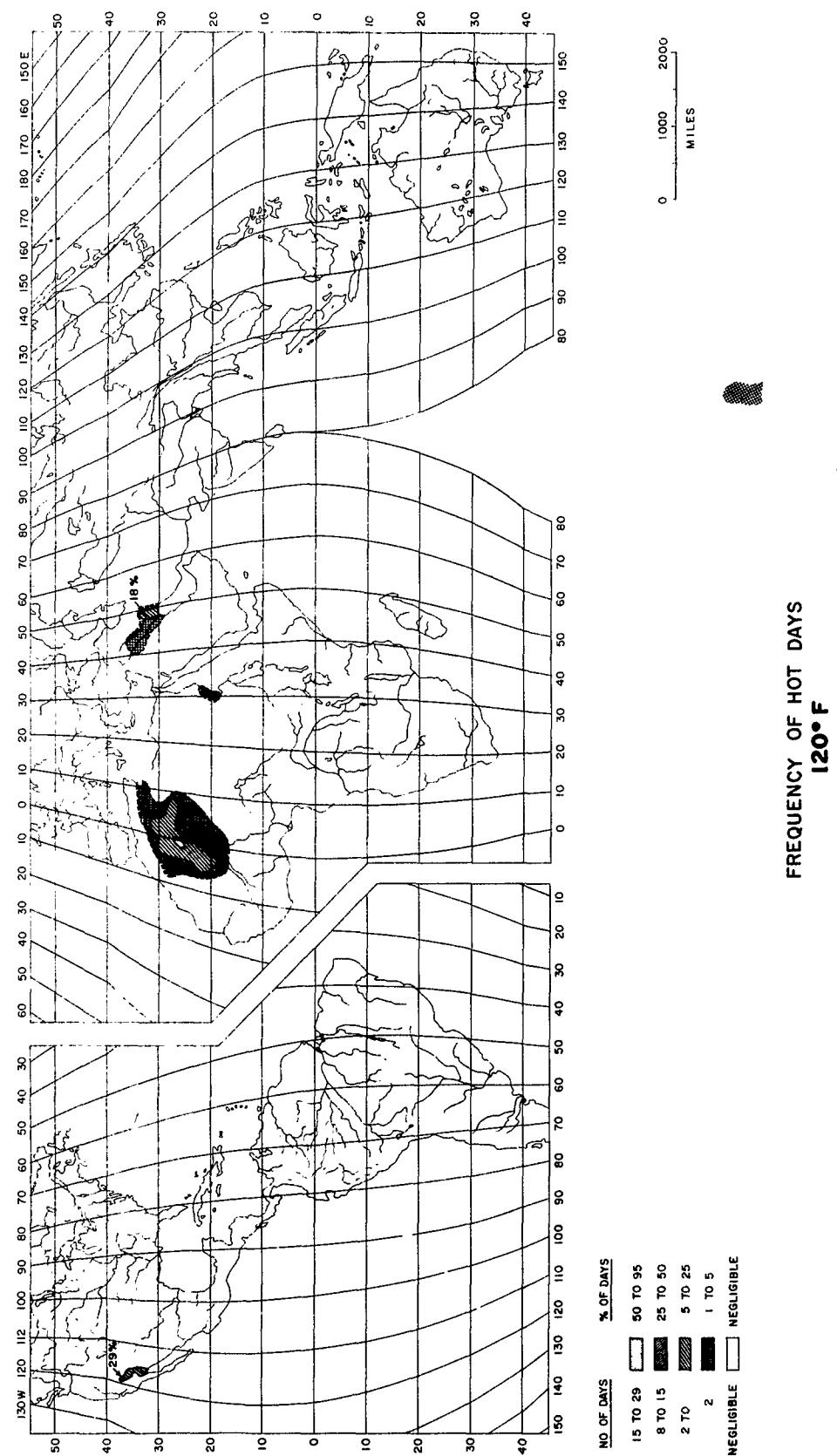


Figure 3. FREQUENCY OF HOT DAYS WITH MAXIMUM TEMPERATURES
AT OR ABOVE 120° F

PROVISIONAL HIGH TEMPERATURE CORRELATIONS (HOTTEST MONTH)

Mean Daily Max. of Month (°F)	Percent Frequency of Days with Max. at or Above	Average Number of Successive Days at or Above				Average Hours Duration of Temperature at or Above			Absolute Max. (°F)		
		110°	115°	120°	110°	115°	120°	110°	115°	120°	125°
115	90	60	13	20	6	3	7	5	4	2	130
110	50	25	2	4	3			5	3	2	125
105	20	7	0	3	2			4	2		120
100	5	2	0	2				2			115
95											
90	0 to 5				0 to 2			0			
85											110 to 115

Solar radiation at the top of the atmosphere, according to Mooney*, is 123 watts per square foot and decreases to 86 watts per square foot at sea level when the sun is directly overhead. The radiation of 105 watts per square foot might occur in the Sahara Desert since it has a higher altitude than does the Mojave Desert.

The daily cycle of solar radiation in the desert is very similar to that of temperature, although the temperature lags behind the sun by a couple of hours. The solar radiation increases from zero intensity to a maximum at noon and then descends to zero. Within two hours of noon, the intensity will vary only 10 percent from the maximum.

B. Design Requirements

It is important to select a practical maximum temperature and radiation as a design nominal. Based on the study conducted on worldwide conditions, the design nominal has been selected as 110°F and 100 watts per square foot. Under such design requirements the missile system could operate normally without artificial cooling throughout the world except for the areas of the west central Sahara Desert, the Nile Valley, the Mesopotamia Valley, the Ganges Valley, the Mojave Desert, and small portions of western Australia, Somaliland, the Western Pampas of Argentina, and the Great Plains of the United States (Figure 2). The missile performance is to be evaluated at conditions above 110°F and 100 watts per square foot to establish a downrated CEP for the reentry body under these conditions. The missile will be required to deliver the reentry body within the relaxed CEP under prelaunch conditions of 125°F and 105 watts per square foot.

III. PROPOSED TESTS

A. Test Description

A series of environmental tests, exposing the missile to a high ambient temperature and solar radiation, are to be performed to gather the necessary temperature data on the guidance and control compartment of the missile. The objective of these tests is to determine whether the cooling cycle of the air conditioner can be eliminated and, if so, at what temperature the guidance and control compartment can operate.

*"Proposed Standard Solar Radiation Curves for Engineering Use"
Journal of the Franklin Institute, Vol. 230, (Nov. 1940)

The test has been divided into four phases. The first three phases will simulate conditions of temperature and solar radiation from a temperate climate to an extremely hot desert climate. In each of the first three phases there shall be at least three cycles, as shown in Figure 4. Each cycle is to consist of a ten-hour soak at a controlled temperature without solar radiation; a five-hour increase in temperature and solar radiation to the desired values; a four-hour soak at constant temperature and solar radiation; and a five-hour decrease in solar radiation and temperature, reducing the radiation to zero and the temperature to the same value as used for the ten-hour soak.

In each of the phases, air will be circulated through the guidance and control compartment when the missile is operating or exposed to solar radiation at temperatures above 77°F. The temperature of the circulating air at the inlet of the missile shall be the same as the ambient temperature of the chamber. The quantity of circulating air will be controlled between zero and 35 pounds of dry air per minute. One cycle of each phase should be run with no air flow to determine the worst conditions the hardware in the guidance and control compartment will be exposed to.

The fourth phase will be performed in a high-temperature environment with solar radiation to determine the length of time that would be required to cool the guidance and control compartment if the air were to start circulating after the missile has been exposed to the environment for approximately five hours. Another objective is to determine the operating temperature of the guidance hardware if the missile were to be run continuously for several hours.

B. Missile Test Specifications

At the start of the test program the missile shall be required to operate within the field level specification. Since the equipment will be operating at temperatures above normal, it may be difficult to differentiate between a failure and degradation of performance due to the environment. Performance outside the specification limit when the missile is operating in other than the normal environment will not be considered a failure. If the environment has a permanent effect on the performance of a component or subsystem, it will be recorded as a failure and an analysis will be performed to locate the cause of the failure.

The Test Engineer will determine when it is necessary to replace or repair a defective component.

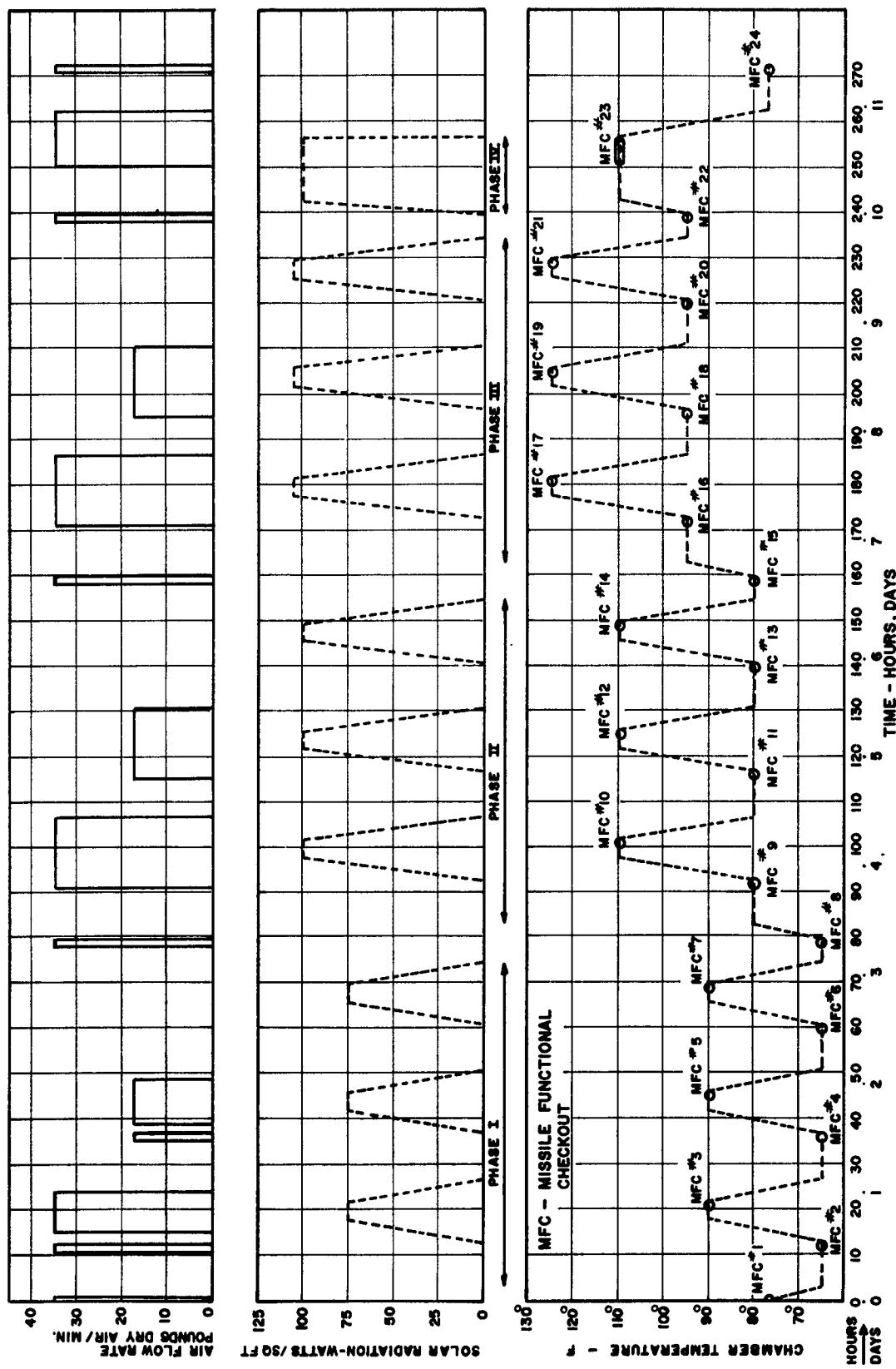


Figure 4. PROPOSED TEST SCHEDULE

IV. HARDWARE AND EQUIPMENT REQUIRED

A. Test Hardware

The missile that is to be used for the test program shall be similar to the tactical configuration. Although only the guidance and control compartment, the second stage, and the warhead would be necessary to fulfill the primary objective of the test program, the complete missile is recommended. Using the whole missile would enable a complete system analysis under an extreme environment in which the PERSHING has not been tested to date.

The missile is to contain all tactical guidance components, but some modifications will be necessary for the test program. The ST-120 pitch cam programmer, located in the Servo Amplifier, should be modified so that the pitch attitude transducer of the ST-120 will have a null output with the missile in the horizontal position. All that is required is a 90°-rotation of the synchro control transmitter of the pitch cam programmer.

The slant altitude program generator module of the guidance computer should also be modified to simulate the conditions of flight in the slant altitude channel and allow the control vanes to operate normally. This modification entails gearing changes in the program generator to subtract the acceleration sensed by the ST-120 slant altitude accelerometer due to gravity, and installing a D-5 cam to provide a controlled error signal to drive the control computer and the control vanes.

Since the missile battery is a one-shot device, it is recommended that a battery simulator be used for this test program. A component test on the battery could be more economically performed later utilizing the data gathered in this system test. The system test would require 22 batteries in all.

B. Test and Checkout Equipment

In addition to the missile, equipment will be required to control the missile circuits. There are two possible choices in the type of equipment to be used -- development equipment or the programmer test station. The equipment is to be capable of functionally testing the missile and all of its components, and of initiating a simulated flight.

1. Programmer Test Station

The programmer test station is designed to perform a prelaunch countdown and functionally test the missile. The information obtained in a functional test is qualitative rather than quantitative, indicating only that the missile is operating within or outside the requirements for flight. If a missile component is operating outside the flight requirements, the primary test station indicates the area in which the malfunction is occurring.

In this test program, it is anticipated that the missile will operate beyond the tolerances required for flight when the compartment temperature exceeds 100°F. Additional equipment would be recommended to monitor the input and output signals of the primary test station so that a malfunction may be more easily located.

The type of test that would be performed by the programmer test station would be similar to the functional test performed with the missile in its shipping container: the voltage and frequency of the inverter are monitored along with the voltages of the dc distribution busses; the ST-120 is operated; and functional tests of the guidance computer, control computer, and exploding bridgewire are performed, along with a simulated flight.

2. Development Equipment

An alternate choice for equipment to operate the missile would be development-type equipment similar to the Simulated Flight Van manufactured by Martin-Orlando for the Test and Evaluation Laboratory. This equipment should be capable of operating, functionally testing the guidance system, and initiating a simulated flight. Functional tests should be performed on the ST-120 stable platform, guidance computer, control computer, exploding bridgewire system, and inverter.

a. ST-120 Tests

The tests that should be performed on the ST-120 stable platform are gyro drift, accelerometer calibration, transient response, excitation voltages and currents, null voltages of servo loops, and pitch cam programmer operation.

Before the gyro drift accelerometer tests can be performed, the latitude, longitude, and firing azimuth of the missile must be known very accurately and, if possible, the firing azimuth should be aligned North-South or East-West. The gyro drift test is to be performed by monitoring the ST-120 attitude signals for six minutes

after the alignment circuits have been disabled. The ST-120 drift along the coordinated axis can then be calculated using the scale factor of the attitude transducers; the components of drift due to earth's rotation are then subtracted, leaving the gyro drift errors for the stabilizing gyros. This method of measuring gyro drift is limited in accuracy but is sufficient for the purposes of this test.

The ST-120 accelerometers are to be calibrated indirectly through servo repeaters in the guidance computer. The time required for the servo repeater monitoring synchro to complete five or fifteen revolutions is to be measured in the slant range and slant altitude channels within an accuracy of one millisecond. The drift of the cross range accelerometer is to be measured for one minute on a drift meter, which indicates degrees of rotation, with an accuracy of $.01^\circ$.

To evaluate the stability of the stabilizing servo loops, the gimbal servo motors are to be individually impaled to obtain a positive and negative impulse of approximately 25 millivolts from the corresponding gyro pickoff. The gyro pickoff signal is to be recorded on a Sanborn recorder or equivalent.

The pitch cam programmer is to function between program zero and the long range 1° limit. The pitch control transformer output and the telemetering pot output are to be recorded at both program zero and the 1° limit.

The following excitation voltages and currents are to be recorded: 115 v 30 400 cps and 28 v dc input to servo amplifier, gyro spin motor excitation voltage and line currents, microsyn pickoff excitation voltage, gyro pickoff excitation, voltage accelerometer fixed-phase excitation voltage, and gyro torquer fixed-phase excitation. The following servo loop voltages and null voltages are to be recorded: gyro pickoff output, accelerometer pickoff output, gimbal servo motor control phase, accelerometer control phase, torquer control phase, pendulum null voltages, and microsyn and pitch control transformer null voltages.

b. Guidance Computer Tests

The tests that should be performed on the guidance computer are zero and offset velocity integration in the lateral channels, zero and .500 m/sec velocity integration in the slant range channel, set "T" tests, cutoff accuracy, and program generator timing functions. For the zero and offset velocity integration tests in the lateral channels, the zero and offset velocities shall be integrated for 100 seconds and 10 seconds, respectively. The displacement channels shall be returned to zero for each integration test and the value of the displacement pot recorded for each integration.

The slant range zero and 500 m/sec velocity are both to be integrated for 100 seconds, and the displacement accumulated read out from the digital presetting counter.

Slant range tests of set "T" and cutoff shall be performed to determine the accuracy of the cutoff null detector and the "T" potentiometer setting. The set "T" potentiometer test should be performed for three flight conditions -- values of "T" for flights of long duration, short duration, and approximately midway between the two. The cutoff accuracy test should be performed to determine the point when arming and cutoff occur for a particular "T" setting.

The program generated should be tested by measuring the time from when program zero is released to T_1 , T_2 , T_3 , and second stage ignition.

c. Control Computer Tests

The control computer tests are to be performed by simulating guidance signals which come from the guidance computer and ST-120 in flight, monitoring the vane position feedback voltages for both the long-range and short-range flight modes, and measuring the output of the ± 25 -volt power supply.

d. Exploding Bridgewire Tests

The exploding bridgewire system is to be tested by monitoring the charging current of the power supply and monitoring the output functions as they occur during the simulated flight. Explosive bolts shall be simulated electrically for purposes of the test program.

e. Inverter Tests

The inverter is to be tested to determine the voltage and frequency output and regulation during countdown and flight conditions.

f. Simulated Flight

A simulated flight is to be performed for each environment and will be the most significant portion of the test, providing integrated information on the missile guidance system.

C. Missile Support Equipment

In addition to the primary test station or R&D test equipment, a source of electrical power, clean high pressure air, and circulating air will be required. The primary power pack or

equivalent could be used to supply both the high pressure air and electrical power for either the primary test station or the R&D test equipment. The air that is to be circulated through the missile can be pumped from the chamber into the missile, provided the moisture content is controlled by passing the air through a desiccant or drying system. Flow rates of 0, 17.5, and 35 pounds of dry air per minute, at the same temperature as the ambient temperature of the chamber, are desired for the test. An air conditioner that is capable of supplying a controlled air flow up to 45 pounds of dry air per minute at temperature between 40°F and 130°F is to be used as an alternate source if the tests indicate refrigerant air is required.

D. Test Chamber

The Test and Evaluation Laboratory at Redstone Arsenal has several test chambers which could be used for this program. Of the two most suitable, the more ideal chamber is the Sunshine Cell located in Building 7290. It is a chamber 37 ft. long, 12 ft. wide, and 14 ft. high with an 8-ft. wide door, and is capable of controlled temperatures between 60°F and 125°F. The Sunshine Cell is permanently equipped for solar radiation tests up to 105 watts per hour.

The second chamber, the conditioning chamber, is located in Building 8540 and is capable of temperatures from -80°F to +180°F. Portable auxiliary equipment can be used to simulate solar radiation up to 105 watts per hour. This chamber is considerably larger than the Sunshine Cell, being 56 ft. long, 28 ft. wide, and 13 ft. high.

Other chambers in Building 7290, similar in size to the Sunshine Cell, are capable of high temperature, low temperature, humidity, salt spray, vibration, fungus resistance, rain, and sand and dust tests in accordance with MIL-E-5272C.

E. Instrumentation

Recording equipment will be required to record the environment, temperature, and performance of the test hardware. Temperature recording instruments and sensors usable in the range of +60°F to +250°F shall be used to monitor the temperatures of approximately 75 different functions at 30-minute intervals when the missile is not operating, and continuously when the missile is in operation. Recording equipment will also be required for approximately 85 guidance functions. A provision for measuring the frequency of the inverter with an accuracy of $\pm .012$ cycles per second will also be necessary. In the appendix are lists of temperature and guidance measurements required for each section of the missile. Most of the measurements are standard measurements established by the Test and Evaluation Laboratory and Martin-Orlando.

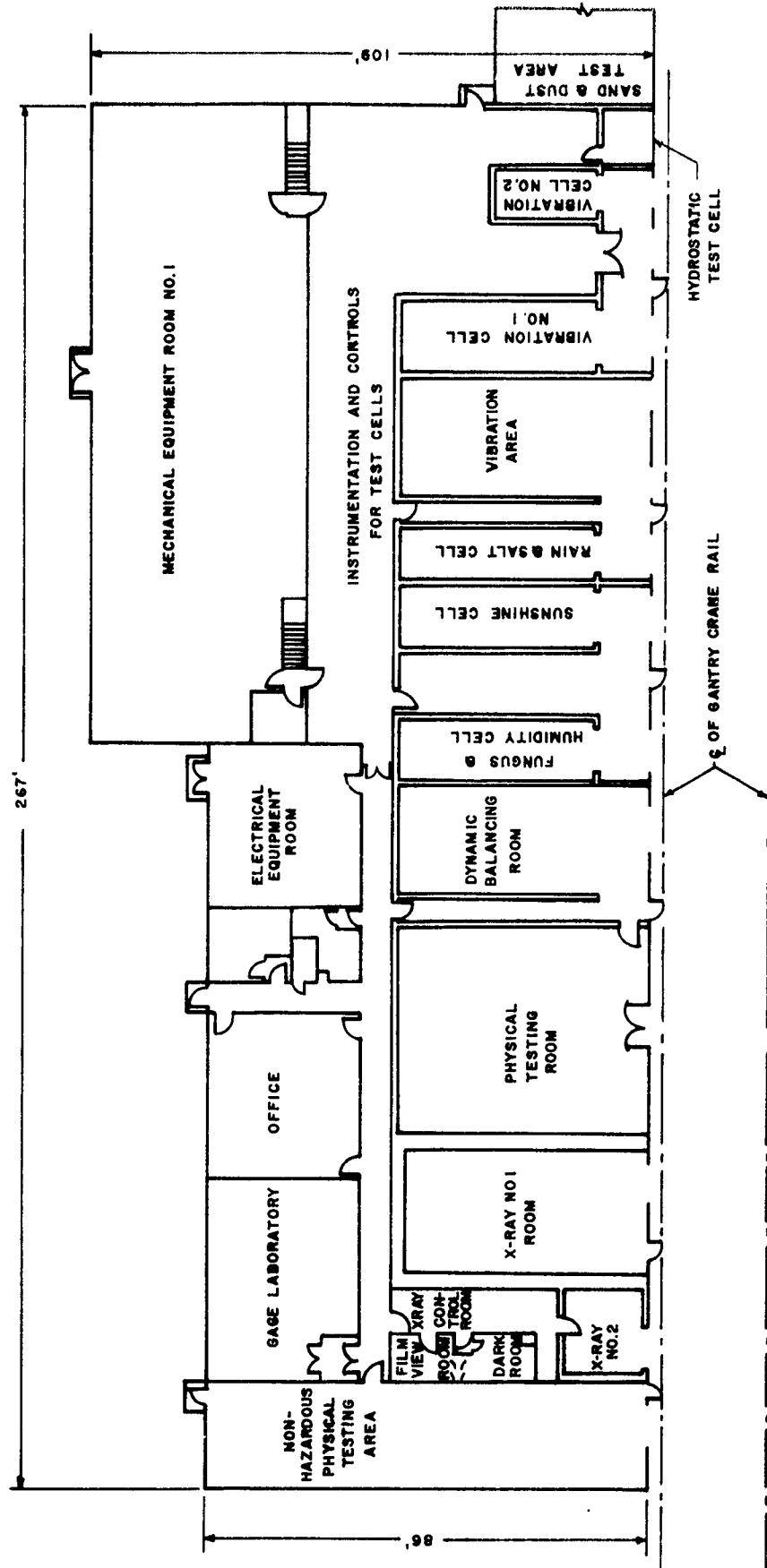


Figure 5. PREFLIGHT EVALUATION LABORATORY AT
BUILDING 7290

F. Miscellaneous Equipment

In addition to the equipment described previously, the following electronic test equipment will be required: two oscilloscopes (sensitivity 10 mv/cm or better); two phase sensitive vacuum tube voltmeters; four volt-ohm multimeters; one differential ac-dc vacuum tube voltmeter (John Fluke); one audio oscillator; and two regulated dc power supplies (one 0-5 volts 10 amps, and one 0-30 volts 5 amps).

Mechanical hardware, such as handling slings for each missile section, a stand to rest the missile on horizontally, and a fork lift, will be necessary to assemble and disassemble the missile during the test.

V. MANPOWER

A. The manpower required for the test program recommended previously has been divided into two groups, the missile test crew and the chamber crew. The missile test crew would be responsible for performing and recording the tests on the missile and reducing the data obtained. The chamber crew would be responsible for controlling the environment, recording all temperature measurements, and reducing the temperature data.

B. The size of the test crew, including contractor support, has been estimated at 16 people, as follows:

- 1 Test Engineer
- 1 Systems Analyst (G&C Lab)
- 4 Chamber Crew (T&E Lab)
- 6 Missile Crew (4 from the T&E Lab and 2 from the G&C Lab)
- 4 Contractor Support (2 representing Martin and
2 representing Bendix)

VI. COST ESTIMATE

A. Since the hardware to be tested and the test equipment have not been assigned to this project, it is difficult to establish a cost estimate. If a properly instrumented missile and suitable test equipment, such as the T&E Lab's Simulated Flight Van or a programmer test station, are available, the cost and time required would be at a minimum.

The information obtained by this project will be most useful if a missile of tactical configuration is used. The three Group V missiles from the 63-64 contract year which have been assigned to reliability tests could easily be adapted for this project. It would not be much more difficult to modify another missile, provided the modifications are performed while the missile is being assembled. Although a Group V missile is recommended for the project, the changes from Group IV to Group V are not serious enough to prevent using a Group IV missile; for Group V the EBW system is to be removed from the G&C compartment and built in modular form, the hydraulic actuators will be replaced by an improved design, and the ST-120 gyro inner cylinders are to be changed from monel to beryllium. Two Group IV missiles are presently being used for reliability tests -- No. 402 is being used for Arctic testing at Fort Wainwright, and No. 401 is being used in static firings at Redstone Arsenal. Although 401 would have to be refurbished and modified for this project, it would be the easiest to adapt if a completely suitable missile cannot be obtained. Missile 402 is scheduled for use in the Arctic through March 1963 and then in the tropics through November 1963.

B. The test equipment presents as much of a problem as the missile. The Simulated Flight Van, which is ideally suited to perform this type of testing, is currently being used by Hayes Aircraft to test missile trainers but should be available in April 1963. As an alternate, the programmer test station can be used to control the missile functions. Each Group V reliability missile will have a complete artillery set, including a programmer test station, but the two Group IV missiles are not associated with a particular programmer test station.

C. Assuming the availability of an instrumented missile and suitable test equipment, the test could be completed in seven weeks by the 16-man team described previously. The cost breakdown would be as follows, allowing some safety margin:

Direct Labor:

Civil Service \$100,000

Contractor Support 25,000 (Based on using 2 in-house contractor employees and 2 from the outside)

Direct Material: 5,000

Total \$130,000

Appendix

TEMPERATURE AND GUIDANCE MEASUREMENT REQUIREMENTS

Appendix

TEMPERATURE AND GUIDANCE MEASUREMENT REQUIREMENTS

1st Stage Measurements

<u>Temperature:</u> (18 Measurements)	<u>Pressure:</u> (9 Measurements)
1.3.81 Motor Case Temperature	1.4.3 Actuator #1 Differential
1.3.100 Air 3" Outboard Nozzle Surface 350°	1.4.4 Actuator #2 Differential
1.3.119 First Stage Compartment Air, Forward End	1.4.5 Actuator #3 Differential
1.3.155 #1 Hydraulic Reservoir Fluid	1.4.20 Hydraulic Pump #1 Outlet
1.3.156 #2 Hydraulic Reservoir Fluid	1.4.21 Hydraulic Pump #2 Outlet
1.3.157 #3 Hydraulic Reservoir Fluid	1.4.22 Hydraulic Pump #3 Outlet
1.3.158 Hydraulic Pump Motor #1 Surface	1.4.23 Hydraulic Pump #1 Inlet
1.3.161 #2 Bearing Cover Inner Surface 300°	1.4.24 Hydraulic Pump #2 Inlet
1.3.162 #1 Bearing Cover Outer Surface 205°	1.4.25 Hydraulic Pump #3 Inlet
1.3.172 Flame Shield Inner Surface 240°	<u>Voltage:</u> (2 Measurements)
1.3.186 Motor Case Surface 0°	1.6.5 Igniter Signal
1.3.189 #1 Hydraulic Actuator Case Surface	1.6.8 Hydraulic Pump Motor #1
1.3.190 #2 Hydraulic Actuator Case Surface	
1.3.191 #3 Hydraulic Actuator Case Surface	<u>Currents:</u> (3 Measurements)
1.3.200 1st Stage Missile Skin	1.7.6 Hydraulic Pump Motor #1
1.3.201 1st Stage Missile Skin	1.7.7 Hydraulic Pump Motor #2
1.3.202 1st Stage Missile Skin	1.7.8 Hydraulic Pump Motor #3
1.3.203 1st Stage Missile Skin	<u>Position:</u> (3 Measurements)
	1.9.1 1st Stage Air Vane #1
	1.9.2 1st Stage Air Vane #2
	1.9.3 1st Stage Air Vane #3

2nd Stage Measurements

<u>Temperature:</u> (15 Measurements)	<u>Pressure:</u> (9 Measurements)
2.3.36 Air 3" Outboard Nozzle Surface 350°	2.4.3 Actuator #1 Differential
2.3.37 Air 3" Outboard Nozzle Surface 110°	2.4.1 Actuator #2 Differential
2.3.38 Air 3" Outboard Nozzle Surface 230°	2.4.5 Actuator #3 Differential
2.3.69 Hydraulic Reservoir #1 Fluid	2.4.20 Hydraulic Pump #1 Outlet
2.3.70 Hydraulic Reservoir #2 Fluid	2.4.21 Hydraulic Pump #2 Outlet
2.3.71 Hydraulic Reservoir #3 Fluid	2.4.22 Hydraulic Pump #3 Outlet
2.3.72 Hydraulic Pump #1 Surface	2.4.23 Hydraulic Pump #1 Inlet
2.3.75 Bearing Cover #2 Inner Surface 300°	2.4.24 Hydraulic Pump #2 Inlet
2.3.80 Bearing Cover #1 Outer Surface 180°	2.4.25 Hydraulic Pump #3 Inlet
2.3.92 Bearing Cover #3 Inner Surface 60°	<u>Voltage:</u> (3 Measurements)
2.3.93 Motor Case Surface	2.6.4 Igniter Command EBW
2.3.100 2nd Stage Missile Skin	2.6.5 Thrust Termination Command
2.3.101 2nd Stage Missile Skin	2.6.8 Igniter Signal
2.3.102 2nd Stage Missile Skin	<u>Currents:</u> (3 Measurements)
2.3.103 2nd Stage Missile Skin	2.7.6 Hydraulic Pump Motor #1
	2.7.7 Hydraulic Pump Motor #2
	2.7.8 Hydraulic Pump Motor #3
	<u>Position:</u> (3 Measurements)
	2.9.1 Second Stage Air Vane #1
	2.9.2 Second Stage Air Vane #2

G&C Compartment Measurements

<u>Temperature:</u>	(23 Measurements)	<u>Voltage:</u>	(38 Measurements)
4.3.1	Rotary Inverter Inlet Air	4.6.1	Inverter \emptyset A 115 v 400 cy
4.3.4	ST-120 Air Bottle	4.6.2	Inverter \emptyset B 115 v 400 cy
4.3.5	Air Bearing Air Supply	4.6.3	Inverter \emptyset C 115 v 400 cy
4.3.7	Control Computer Internal Air	4.6.4	D-11 Bus 28 v dc
4.3.8	Control Computer Surface	4.6.5	D-21 Bus 28 v dc
4.3.10	Main Distributor Surface	4.6.6	ST-120 Attitude \emptyset Y $0\pm$ 50 mv 400 cy AC \emptyset
4.3.11	Power Distributor Surface	4.6.7	ST-120 Attitude \emptyset X $0\pm$ 50 mv 400 cy AC \emptyset
4.3.13	Servo Loop Amplifier	4.6.8	ST-120 Gyro Motor Excitation \emptyset A 27 v 400 cy
4.3.17	ST-120 Mounting Area	4.6.9	ST-120 Gyro Motor Excitation \emptyset B 27 v 400 cy
4.3.18	G&C Compartment Aft (Air)	4.6.10	ST-120 Gyro Motor Excitation \emptyset C 27 v 400 cy
4.3.20	Guidance Computer Base Plate Temperature	4.6.11	ST-120 Gyro Motor Excitation \emptyset A 27 v 400 cy
4.3.21	ST-120 Carrier Ring	4.6.12	Accel Preamp Output CR 0 ± 80 mv 400 cy AN \emptyset
4.3.22	Servo Amplifier Internal Air	4.6.13	Accel Preamp Output SR 0 ± 80 mv 400 cy AN \emptyset
4.3.23	Guidance Computer Internal Air	4.6.14	Accel Preamp Output SA 0 ± 80 mv 400 cy AN \emptyset
4.3.24	Rotary Inverter Regulator Surface	4.6.15	Gyro Pickoff Output Y 0 ± 50 mv 400 cy AN \emptyset
4.3.25	G&C Compartment Air Forward Section	4.6.16	Gyro Pickoff Output X 0 ± 50 mv 400 cy AN \emptyset
4.3.26	Circulating Air Inlet	4.6.17	Gyro Pickoff Output Z 0 ± 50 mv 400 cy AN \emptyset
4.3.27	Circulating Air Outlet	4.6.18	ST-120 Gimbal Servo Motor Y 0 ± 20 v 400 cy AN \emptyset
4.3.28	G&C Compartment Missile Skin	4.6.18	ST-120 Gimbal Servo Motor X 0 ± 20 v 400 cy AN \emptyset
4.3.29	G&C Compartment Missile Skin	4.6.20	ST-120 Gimbal Servo Motor Z 0 ± 20 v 400 cy AN \emptyset
4.3.30	G&C Compartment Missile Skin	4.6.21	Accelerometer Servo Motor CR 0 ± 20 v 400 cy AN \emptyset
4.3.31	G&C Compartment Missile Skin	4.6.22	Accelerometer Servo Motor SR 0 ± 20 v 400 cy AN \emptyset
4.6.23	Accelerometer Servo Motor SA 0 ± 20 v 400 cy AN \emptyset		

G&C Compartment Measurements (Continued)

<u>Voltage:</u>	(Continued)	<u>Pressure:</u>	(2 Measurements)
4.6.24	SAV Servo Error	ST-120 Inlet	20-25 psig
4.6.25	SRV Servo Error	Air Bottle	
4.6.26	CRV Servo Error		
4.6.27	SRV T/M Pot 0-5 v dc		
4.6.28	SRD T/M Pot 0-5 v dc		
4.6.29	SAV T/M Pot 0-5 v dc	4.7.1	Inverter Ø A
4.6.30	SAD T/M Pot 0-5 v dc	4.7.2	Inverter Ø B
4.6.31	CRV T/M Pot 0-5 v dc	4.7.3	Inverter Ø C
4.6.32	CRD T/M Pot 0-5 v dc	4.7.6	Gyro Motors Ø A .6v/amp 0.6 amp
4.6.33	ST-120 Microsyn Excitation 26 v 400 cy	4.7.7	Gyro Motors Ø B .6v/amp 0.6 amp
4.6.34	1st Stage Separation Command 28 v dc	4.7.8	Gyro Motors Ø C .6v/amp 0.6 amp
4.6.35	Pitch Cam BT/M Pot 0-5 v dc	4.7.9	Accel Motors Ø A .6v/amp 0.4 amp
4.6.36	Gyro P. O. Excitation 5 v 400 cy	4.7.10	Accel Motors Ø B .6v/amp 0.4 amp
4.6.37	Guidance Computer Signal 28 v dc	4.7.11	Accel Motors Ø C .6v/amp 0.4 amp
4.6.39	Cutoff Signal EBW 5 v dc		
			<u>Frequency:</u> (1 Measurement)
4.8.1	Rotary Inverter 400 cy \pm .012 cps		

Warhead Measurements

8 Temperature measurements

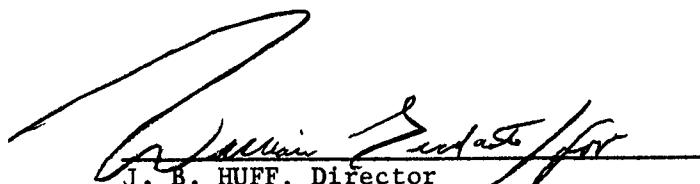
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3. Meigs, P., Frequency and Duration of High Temperatures, Environmental Protection Division, Special Report 61, Quartermaster Research and Engineering Center, Natick, Massachusetts (August 1953)

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APPROVED:



J. B. HUFF, Director
Guidance & Control Laboratory, DR&D

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